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Improvement of the Performance for an Absorption Refrigerating System with Lithium bromide-water as Refrigerant by Increasing Absorption Pressure[1]

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♣**Abstract:** Because the absorption refrigeration system uses the Lithium bromide- water solution as refrigerant, it is profitable for the environment that human beings are living since the values of ODP and GWP of the refrigerant almost are zero. However, the low COP of the absorption machine was limited seriously to compete with the refrigeration machine that is drove by electricity. Therefore, most researchers focus their attention on the improvement of performance of the absorption system through many approaches. In this paper, an improved cycle was adopted to raise the pressure inside the absorber of the machine in order to intensify the absorption effect of thick Lithium bromide solution and enhance the COP of the absorption refrigeration system. A mathematical model that is used for predicting the performance of the system will be established, and the influence of pressure change on the overall performance of the machine will be discussed in the paper.

Key words: pressure change, absorption refrigeration system, Lithium bromide

1. INTRODUCTION

It has been recognized gradually that the Lithium-bromide absorption chiller (LBAC) has the advantages such as utilizing the low-level heat energy, lightening the pressure of electricity rush hour by consuming the natural gas for the chiller in summer and the less pollution for environment[1]. However, the chiller is concerned with the high manufacturing cost, considerable experimental cost and the long designing period. Therefore, there are a lot of jobs to do to improve the efficiency of LBAC such as intensifying the heat and mass transfer in evaporator, absorber, condenser and heat exchangers. It is known that the absorber is a key component for the LBAC. The approaches to improve the absorption performance of the absorber generally include declining the temperature of thick solution of Lithium-bromide with water, increasing the concentration of the solution and enhancing the absorption pressure of water steam to be absorbed. Along with the development of computer simulative technology, the performance of the chiller can be predicted, the design scheme of LBAC can also be compared with each other by using simulative results, and the thermodynamic parameters can be optimized. Based on, in the paper, a set of mathematical models and the relevant computing programs, the properties of solution of Lithium-bromide with water could be calculated; In addition, the performance of LBAC could be predicted. Specially, the influence of absorption pressure on the absorption ability of the absorption in the LBAC will be computed and compared in order to lay a theoretical foundation of improving the performance of whole LBAC.

2. THE PRINCIPLE OF ENHANCING ABSORPTION EFFICIENCY OF THE ABSORBER

It is well known that the absorption of

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Lithium-bromide with water solution is the process of water steam molecule dissolving into thick solution, that is, the process of mass transfer. As the mass transfer increasing, the absorption ability of Lithium-bromide with water solution can be enhanced. It means that the effective cooling capacity of LBAC would improve at the same working conditions. The rate of mass transfer of water steam can often be computed by[2]:

$m_{tra} = K_m \cdot F \cdot \Delta m$, Where, m_{tra} displays the rate of mass transfer, K_m shows the coefficient of mass transfer, F means the area of contacting surface for mass transfer between liquid and vapor, and Δm is the driving source of mass transfer. It could get benefit of mass transfer if increasing the any value of three items right above equation.

According to the double membranes theory[1] of mass transfer, for item Δm, it covers two contents: (1) the pressure difference between the pressure of water vapor that would be absorbed p_{wa}, and the average pressure of absorb ant Lithium-bromide with water solution p_{av}, i.e. $p_{wa} - p_{av}$;

(2) the concentration difference between the thick Lithium-bromide with water solution before absorption of water vapor ξ_{th} and the dilute solution after absorption of water vapor ξ_{di}, i.e. $\xi_{th} - \xi_{di}$. Increasing any one of two approaches of the pressure difference and the concentration difference will improve the absorption ability of absorber and the efficiency of LBAC.

3. SIMULATING THE PROPERTIES OF LITHIUM-BROMIDE WITH WATER SOLUTION AND A CYCLE OF SINGLE EFFECT LBAC

It is an important basic for simulating the cycle of LBAC to develop a set of program used for computing the thermal physical properties of Lithium-bromide with water solution such as the special enthalpy, pressure, temperature, concentration, etc. A set of software in VB Language for the purpose has been set up as shown in Fig.1.

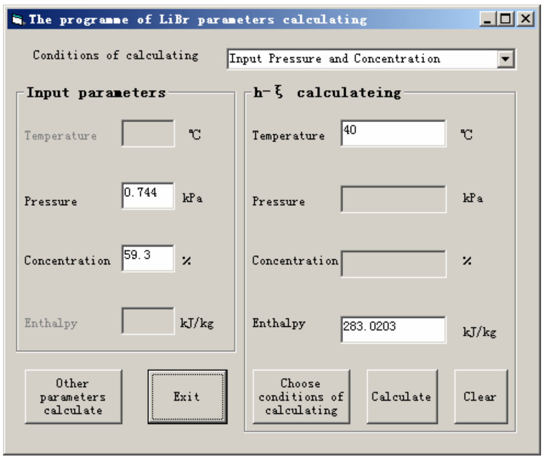


Fig. 1 The interface computing the thermal physical properties of Lithium-bromide with water solution

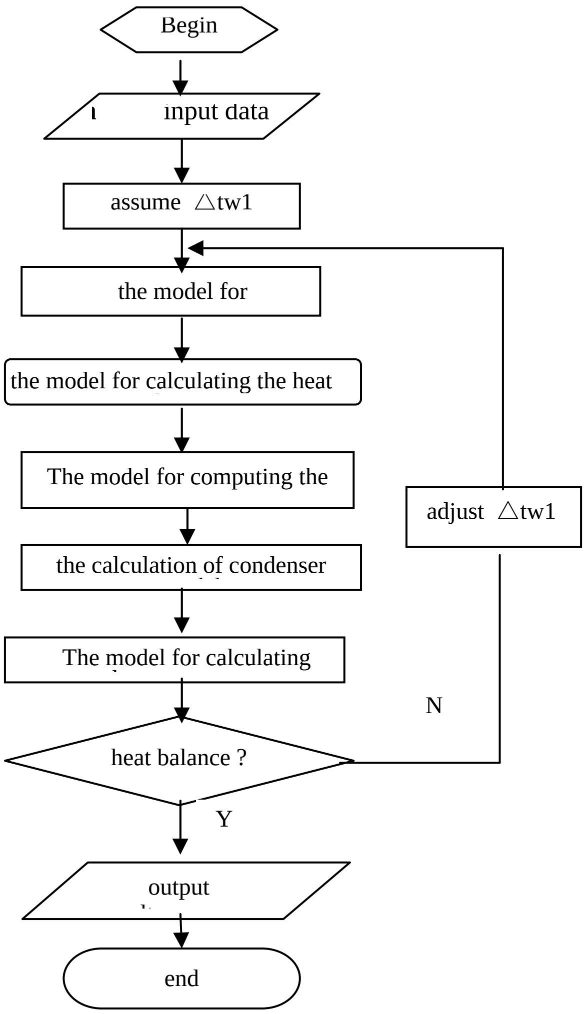


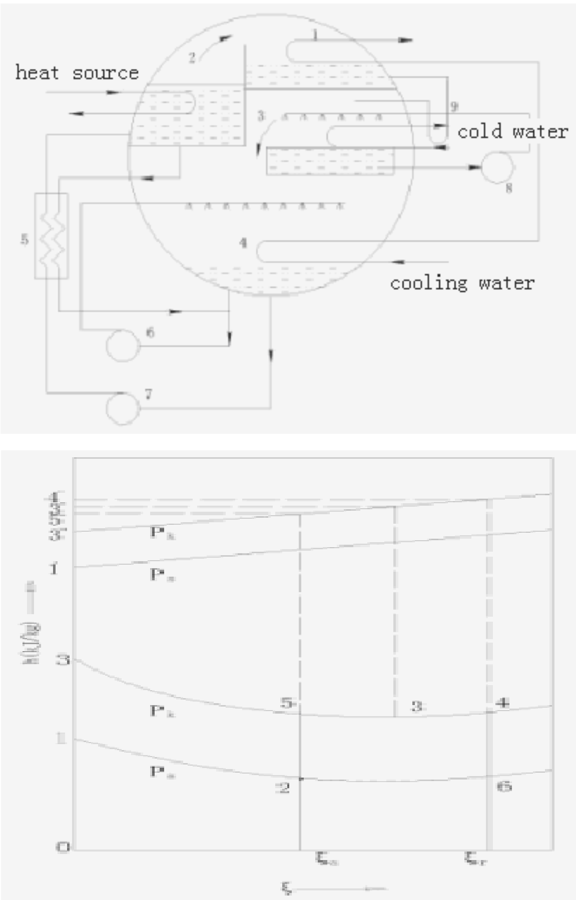
Fig. 2 The logic diagram of simulating the

Lithium-bromide absorption chiller

The logic diagram of the Lithium-bromide absorption chiller is displayed as shown in Fig.2. The flow chart displays the simulative process of the LBAC with a heat exchanger for the heat exchange between the thick solutions of Lithium-bromide and the thin solution during operation of the chiller.

4.RESULTS SIMULATED AND DISCUSSED

Based on the software described above, in the paper, the influence of the pressure of water vapor to be absorbed in the absorber on the absorption ability of Lithium-bromide with water solution and the efficiency of the LBAC would be simulated and discussed.



1 —— condenser; 2 —— generator; 3 —— evaporator; 4 —— absorber ; 5 —— heat exchanger; 6、7、8——pumps; 9——U tube

Fig. 3 The flow chart of a single effect LBAC

Fig.3 [3] shows the flow chart of a single effect LBAC. For the cycle, the refrigerating capacity and the coefficient of performance (COP) would be predicted by using the software when considering the influence of absorption pressure change. The simulation is based on the below assumptions:

(1) the temperature of thin solution in absorber keeps constant when water vapor saturated pressure increases;

(2) the pressure of generator and the heat consumed would be unchanged;

(3) the state parameters in condenser and evaporator such as temperature and pressure are constants.

As a reference working state, as shown in Fig.4, the single effect LBAC would run at some working conditions that are displayed in Tab. 1. Some results simulated are shown in Fig.4. Fig.5 shows the results simulated when changing the absorption pressure from 0.744kPa into 1.2kPa under the other working parameters, shown in Tab. 1, keep unchanged.

Tab. 1 Some running parameters of LBAC as a reference working state

Contents	Values
Evaporating temperature (°C)	3
Evaporating pressure (Pa)	0.744
Condensation temperature (°C)	45
Condensation pressure (kPa)	9.6
Temperature of thick solution in absorber (°C)	40
Absorption pressure (kPa)	0.744
Inlet temperature of cold water (°C)	32
Outlet temperature of cold water (°C)	40
Inlet temperature of cooling water (°C)	15
Outlet temperature of cooling water (°C)	5

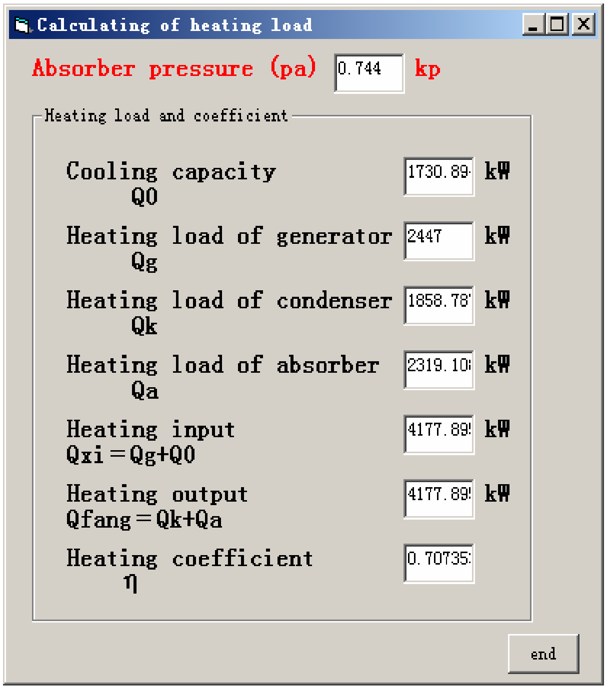


Fig.4 The reference thermal state parameters for the single effect LBAC simulated

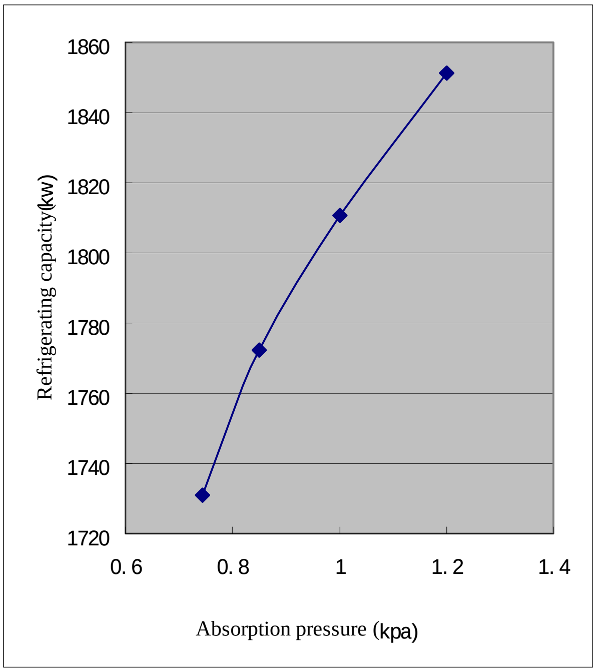


Fig.6 The refrigerating capacity of the single effect LBAC varies as the absorption pressure

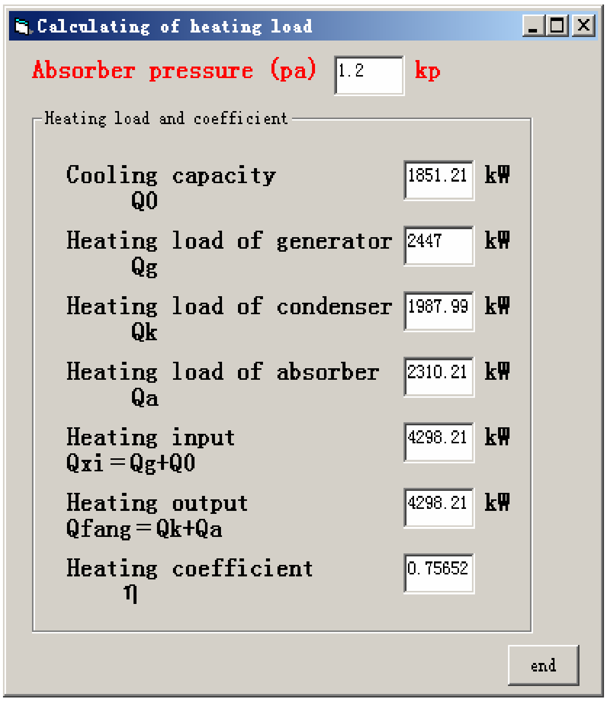


Fig. 5 The simulated thermal state parameters for the single effect LBAC when changing the absorption pressure

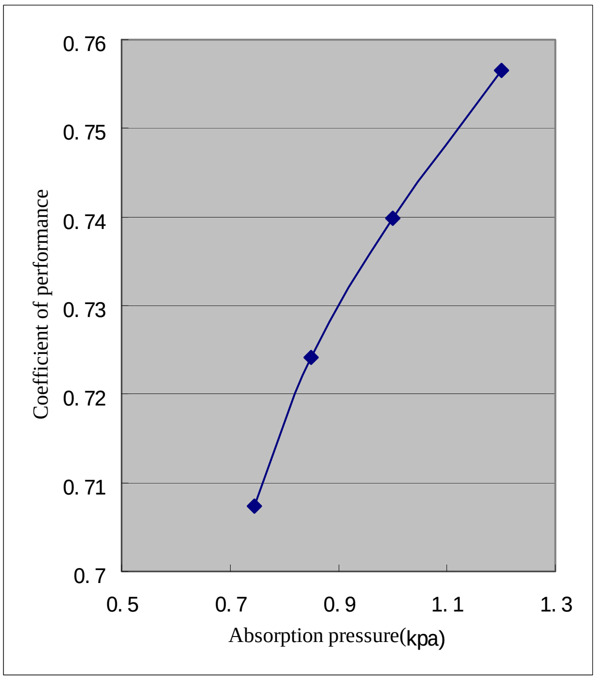


Fig. 7 The coefficient of performance of the single effect LBAC varies as the absorption pressure

Fig.6 and Fig.7 describe the refrigerating capacity and the coefficient of performance (COP) of the single effect LBAC varies as the absorption pressure. It could be seen, from two figures, which the refrigerating capacity and the coefficient of performance enhance as the absorption pressure in the absorber increases. When the absorption pressure value is raised from 0.744kPa to 1.2kPa, the refrigerating capacity of the LBAC can be increased from 1730.89kW to 1851.21kW. The increment is 6.95%. The relevant coefficient of performance (COP) is up from 0.704 to 0.7565; percentage of increment is 4.91%. The results above make out that it is benefitable for the refrigeration system of LBAC to increase reasonably the absorption pressure because it intensifies the pressure difference between the water vapor and the Lithium-bromide with water solution, i.e. intensifying the driving power for absorption.

5. CONCLUSIONS

By means of the tool of simulation, a set of software used for computing the thermal physical properties and predicting the performance of a single effect or double effect LBAC have been got. Based on the software, some performance, such as refrigerating or COP, of the single effect LBAC were predicted, and got useful results: the efficiency of LBAC cycle could be improve by increasing the absorption pressure. These results have laid a fundament for investigating further and promoting the performance of LBAC.

Nomenclatures

F ----- heat transfer area, m^2;

K ----- the coefficient of mass transfer;

m ----- mass, kg;

p ----- pressure, kPa.

ξ ----- concentration of Lithium-bromide with water solution.

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